INSTRUCTION BOOK

MODEL 51-A

AC NULL DETECTOR

326910-1

STABRO
TECHNICA
DOCUMENT

BOONTON ELECTRONICS CORPORATION

MP MASTER
MA24684

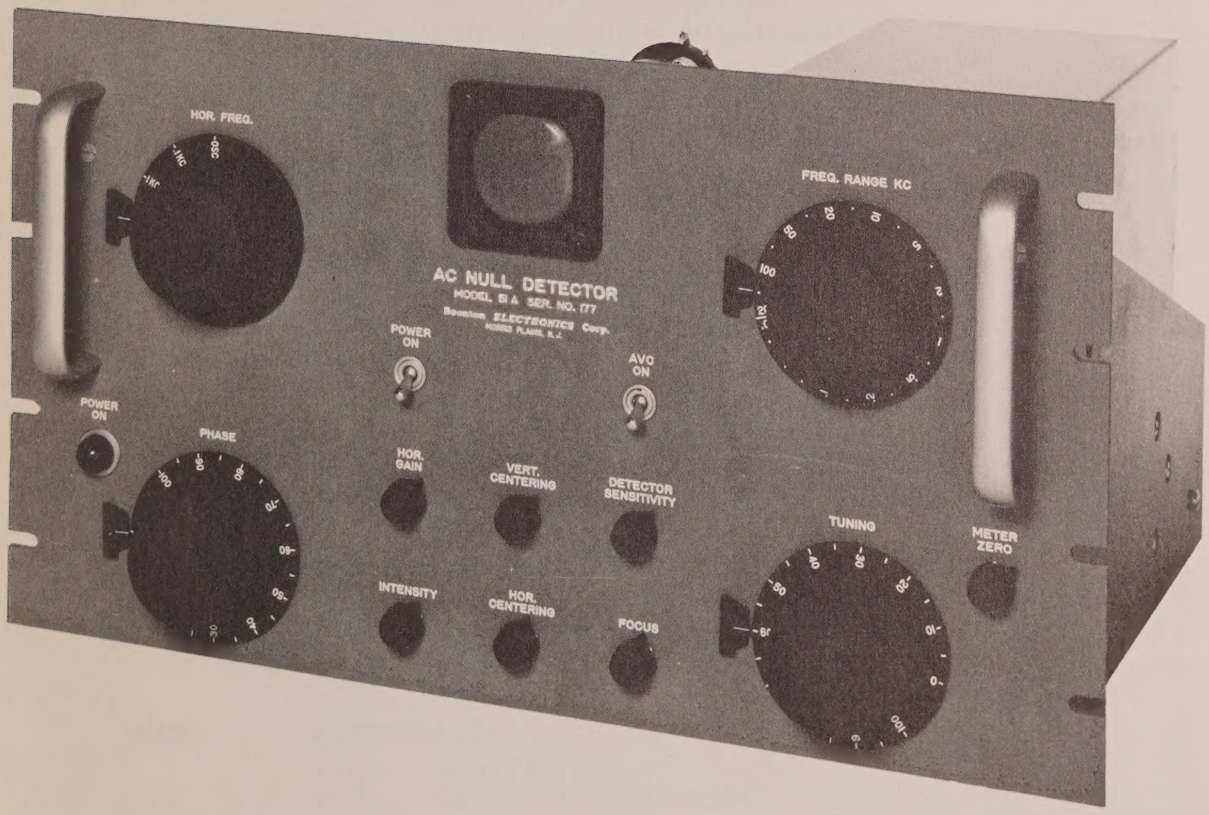
INSTRUCTION BOOK

MODEL 51-A

AC NULL DETECTOR

326910-1

STABRO LABORATORIES, IN
TECHNICAL REFERENCE LIBR
Chris Warren
DOCUMENT CONTROL ADMINISTRA



PLEASE RETURN
TO
METERS & STANDARDS
ROOM

SID 138254 G4

51A
10-63

BOONTON ELECTRONICS CORPORATION
TELEPHONE: 201-887-5110
TWX: 201-887-5059
ROUTE 287 AT SMITH ROAD
PARSIPPANY, N. J.— 07054

TABLE OF CONTENTS

Section		Page
I	SPECIFICATIONS	1
II	GENERAL DESCRIPTION	3
III	PRINCIPLE OF OPERATION	4
	3-1. Vertical Amplifier	4
	3-2. Horizontal Amplifier	4
	3-4. Hunting Range Adjustment	5
IV	INSTALLATION	6
V	OPERATION	7
	5-1. Preliminary Adjustments	7
VI	BRIDGE OPERATIONS	9
	6-1. Operation as Bridge Detector Using the Cathode Ray Tube	9
	6-2. Operation as a Bridge Detector Using a D-C Milliammeter - 1 ma Full Scale Indicator	9
	6-3 Operation as a Limit Indicator	9
	6-7 Tolerance Limit of the Plus and Minus Type	10
	6-8. Tolerance Limit of one Direction - Either Plus or Minus Type	10
	6-9 Operation as a Peak Voltmeter	11
	6-10. Operation as a Wave Analyzer	11
VII	MAINTENANCE	12
	7-1. General	12
	7-2. Vacuum Tube Checks	12
	7-3. Electrolytic Condensers	12
	7-4. D-C Voltage Measurements	12
VIII	TABLE OF REPLACEABLE PARTS	16
IX	SHIPPING INSTRUCTIONS	20
	WARRANTY	21

Digitized by the Internet Archive
in 2025

https://archive.org/details/manualsplus_06216

LIST OF ILLUSTRATIONS

Figure		Page
1	CRT Scales	14
2	Block Diagram 51-A AC Null Detector	15
	Schematic	Backfold

SECTION I

SPECIFICATIONS

Frequency Range:	The nominal frequency range of the detector is 20 cycles to 200 kilocycles per second in twelve ranges: 20-50; 50-100; 100-200; 220-500; 500-1000 cycles per second and 1-2; 2-5; 5-10; 10-20; 20-50; 50-100 and 100-200 kilocycles per second. A continuously variable adjustment is provided to handle any frequency within any of these ranges.
Sensitivity:	Its sensitivity is approximately 10 microvolts for one quarter of an inch deflection peak to peak of the vertical trace on the cathode ray tube indicator and/or a 0.1 milliampere deflection on a suitable d-c meter.
Discrimination:	Its discrimination against the second harmonic of the frequency to which it is tuned is at least 40 db for frequencies up to 50 kilocycles and 35 db for higher frequencies.
Input Impedance:	Its imput impedance is approximately 1 megohm shunted by 100 μμf.
Indicators and Hunting Range:	A 2 inch cathode ray tube is provided as an integral part of the detector for indicating purposes and a jack is also provided to receive a 1 milliampere full scale d-c meter. The meter and C.R. tube can be used simultaneously. When the AVC switch is in the "OFF" position the hunting range with either of these indicators is approximately 25 db; in the "ON" position it is approximately 75 db.

SPECIFICATIONS (cont'd)

Controls and External Connections:	All the controls for the detector are mounted on the front panel. They provide means for adjusting intensity, focus, the vertical and horizontal positions of the C.R. tube pattern, frequency, phase and sensitivity of the horizontal and vertical deflecting plate amplifiers, and the zero adjustment for the external meter. All external connections to the chassis are made through jacks and plugs located at the rear of the detector.
Power Supply:	The power supply is self contained for use on a nominal 120 Volt, 60 cycle source. The power consumption of the detector is approximately 85 watts.

SECTION II

GENERAL DESCRIPTION

2-1. The 51-A Detector is a sensitive cathode ray or meter indicating type detector with provision for discriminating against all frequencies but the one it is adjusted to transmit. Its prime function is that of a null detector for use with low frequency impedance bridges. It can be adjusted to indicate at a glance when predetermined limits are exceeded by apparatus measured on such a bridge. It can be calibrated to be used as a peak voltmeter or as a wave analyzer.

2-1. It has a self contained power supply and is intended to operate on 120 volts 60 cycles and uses approximately 85 watts of power.

SECTION III

PRINCIPLE OF OPERATION

3-1. Vertical Amplifier

The principle of operation is explained by referring to the block diagram attached. The bridge output signal is amplified first by a 6AK5 vacuum tube amplifier. This signal is fed to a two stage selective feed-back amplifier consisting of a 6GH6 tube used as a direct coupled amplifier followed by another 6BH6 tube used as a cathode follower around which a parallel-tee feedback network is connected. Thus the desired signal is amplified while all other frequencies are attenuated. The output of this amplifier is fed into a 6AC7 tube and thence to the vertical deflecting plates of the 2BP1 Cathode Ray tube. Another branch is taken from the output of the 6AC7 tube and fed into a 6J5 tube amplifier followed by a 6H6 diode circuit in order to permit the use of an external meter if desired.

3-2. Horizontal Amplifier

Another set of four input jacks are provided to receive the output directly from the oscillator which feeds the bridge, or from one of several standard frequencies for appearance on the horizontal axis of the cathode ray tube. These inputs are selected by means of a four position switch accessible on the front panel and are fed into a 6SL7 Vacuum tube used as an inverter, and then through an adjustable phase shifting network into a second 6SL7 tube used as a balanced amplifier. The output of this tube is applied across the horizontal plates of the cathode ray tube as described previously.

3-3. The two signals referred to in paragraphs 3-1 and 3-2 are applied to the cathode ray tube and result in a pattern which may be controlled by the "SENSITIVITY" control of the vertical amplifier and the "Gain" and "Phase" controls for the horizontal amplifier. By proper adjustment this figure will indicate independently variations of both magnitude and sign for each arm of the associated bridge.

3-4. Hunting Range Adjustment

An AVC switch is provided which when thrown to "ON" will change the hunting range of the detector from approximately 25 db to 75 db. This introduces an advantage when the detector is used for balancing a bridge, since less manipulation of the sensitivity control is required. In addition, the nearer the null point on the bridge is approached the greater the sensitivity will become.

SECTION IV

INSTALLATION

4-1. The manner in which the detector is connected to the associated equipment is as follows. At the rear of the chassis insert the power line plug connected to a 120 volt, 60 cycle source into receptacle J7. Connect by means of coaxial cables the bridge detector output to J1 of the detector and the oscillator output to J5. Also connect J4, J3 and J2 to 100 cycle, 1 KC and 10 KC frequency standards, respectively if frequency checking is desired. Connect a 1 milliampere full scale d-c meter to J6 by means of a plug*, with the negative terminal connected to the tip and the positive terminal to the ring.

4-2. A substantial copper grounding buss terminating in a good building ground should be connected to the chassis.

* Three circuit microphone plug such as W.E. 310A.

SECTION V

OPERATION

5-1. Preliminary Adjustments

Operate the power switch to ON. Rotate the SENSITIVITY control to its extreme counter-clockwise position. Operate the FREQ. RANGE dial to the band which includes the frequency of the desired signal. Operate the AVC switch to OFF.

5-2. Adjust the INTENSITY and FOCUS until the line on the cathode ray tube screen is sufficiently bright to be observed readily and has sharp definition. Adjust the HORIZONTAL GAIN control so that the horizontal line is approximately one half of the tube diameter. Adjust the VERTICAL and HORIZONTAL CENTERING controls until the line is located in the center of the cathode ray tube screen. Adjust the "ZERO ADJ." control so that the external meter indicates zero. Increase the SENSITIVITY control to its full clockwise position.

5-3. Adjust the TUNING dial until the vertical line on the cathode ray tube screen and/or the meter deflection are at their maximum, reducing SENSITIVITY when necessary, to keep the line approximately 1 inch and/or the meter approximately .2 ma. Above 50 KC the input signal should not be greater than .01 volt.

5-4. Adjust the HORIZONTAL FREQUENCY DIAL to the frequency to be applied to the horizontal plates of the cathode ray tube. In order to check the frequency of the bridge oscillator against the standard frequency, the desired standard frequency is selected by the position of the HORIZONTAL FREQUENCY switch and the oscillator frequency is determined in the usual way by means of the resulting Lissajou figures. The TUNING dial will require adjustment as the oscillator is varied.

5-5 When the oscillator setting has been checked, return the HORIZONTAL FREQUENCY switch to its "OSC" position.

The figure on the cathode ray tube screen then will become an ellipse which may be varied by adjusting the PHASE dial so that its axes are rotated with respect to the vertical. If this figure is not an ellipse make certain that the TUNING dial is correctly adjusted to locate the maximum vertical deflection. Various incorrect figures may result if the TUNING dial is set to the proper line frequency or one of its harmonics or to a harmonid of the bridge oscillator frequency instead of its fundamental.

5-6. As the figure on the cathode ray tube screen is made larger, the INTENSITY and FOCUS dials may require readjustment.

SECTION VI

BRIDGE OPERATIONS

6-1. Operation as Bridge Detector Using the Cathode Ray Tube

Adjust the detector as indicated in paragraph 5-1 Operate the AVC switch to ON. Set the HORIZONTAL GAIN control to its fully counter-clockwise position and adjust the SENSITIVITY control so that approximately one-third of the full scale vetical deflection is obtained on the cathode ray tube. Adjust the HORIZONTAL GAIN control until an ellipse is formed. Adjust the PHASE control until the major axis of the ellipse is deflected by a variation of the reactance dials of the bridge. With this condition, the ellipse will roate so that the major axis will become horizontal with the approach of the reactance arm to balance and the minor axis will shrink with the approach of the resistance arm to balance. As the pattern is so reduced the detector SENSITIVITY is increased and the process continued until a satisfactory bridge balance is arrived at. Operate the HORIZONTAL FREQUENCY switch to a position other than "OSC" and make final adjustments of both of the bridge arms until the cathode ray tube pattern becomes a horizontal line.

6-2. Operation as a Bridge Detector using a D-C Milliammeter 1 ma Full Scale Indicator

Adjust the detector as outlined under paragraph 5-1. Operate the AVC switch to "ON". Adjust the SENSITIVITY until the meter deflects to full scale. Adjust the bridge arms until a minimum meter deflection is obtained with the SENSITIVITY adjusted to maximum. Operate the AVC switch to "OFF". Continue to balance the bridge for a minimum meter deflection.

6-3. Operation as a Limit Indicator

Place the transparent scale, Boonton Electronics Corp. Part #775,101 (Bell Telephone Laboratories Dwg. EST-664,005) so that the disc is centered on the

cathode ray tube screen and the light line on it covers the horizontal trace when the vertical trace is reduced to zero.

6-4. Use a unit of the product, which is known to be within requirements. Adjust the detector as outlined under paragraph 6-3

6-5. Upset the bridge balance by adjusting its reactance arm to a value which differs from the balanced value by the tolerance limit. Adjust the SENSITIVITY and PHASE controls of the detector until the pattern on the cathode ray tube screen is a line, the slope of which coincides with one of the dotted lines of the scale.

6-6. When a series of units are tested the line on the cathode ray tube screen will open to an ellipse by an amount dependent upon the variation of the resistance component of the product. If the opening becomes excessive it may be closed for each unit by adjustment of the resistance arm only of the bridge.

6-7. Tolerance Limit of the Plus and Minus Type

Proceed as in paragraph 6-3 but adjust the reactance arm of the bridge to the nominal value of the product (not the value of the original unit used). Any unit then inserted as the bridge unknown which results in the cathode ray tube pattern being deflected within the area subtended by the two dotted lines of the scale will be within the desired limits.

6-8. Tolerance Limit of One Direction-Either Plus or Minus Type

Proceed as in paragraph 6-3 but adjust the reactance arm of the bridge to the value of the limit desired. Adjust the SENSITIVITY control to produce a cathode ray tube pattern which is just within the area subtended by the two dotted lines. Any unit then inserted as the bridge unknown which results in the cathode ray tube screen pattern being a horizontal line or a line sloping the same direction as it did when

the original unit was used will be within the desired limits.

6-9. Operation as a Peak Voltmeter

Place a transparent scale, Boonton Electronics Corp. Part #775,102 (Bell Telephone Laboratories Drawing ESP 664,065 Detail 1) so that the disc is centered on the cathode ray tube screen and one of the heavy lines covers the horizontal trace when the vertical trace is reduced to zero. Adjust the detector as outlined under paragraph 5-1. Set the HORIZONTAL GAIN control to minimum. By the use of a vacuum tube voltmeter and an attenuator both the deflection on the cathode ray tube screen and on the external meter may be calibrated for a measured voltage.

6-10. Operation as a Wave Analyzer

Proceed as in paragraph 6-9. With the aid of a variable oscillator, the TUNING dial may be calibrated at each setting of the FREQ. RANGE dial for frequency and level for a constant deflection of the indicators. The frequency of the oscillator may be checked against the standard frequency as outlined in paragraph 5-1.

Having this information and providing the levels of discrimination permit, the detector may be used as a wave analyzer of complex waves.

SECTION VII

MAINTENANCE

7-1. General

Maintenance required on the detector is expected to be slight. The power supply input is protected with two (2) Buss type MDL 8/10 fusetrons rated at 8/10 Ampere continuous current.

7-2. Vacuum Tube Checks

At convenient intervals not to exceed one year all vacuum tubes except the 2BP1 should be tested for transconductance in a good tube tester* and all doubtful tubes should be replaced. At other times questionable tubes should be checked in the tube tester and replaced if found defective.

7-3. Electrolytic Condensers

Some electrolytic condensers are included in the set. These should be replaced whenever evidence of their deterioration is observed. Their normal life expectancy is approximately eight (8) years.

7-4. DC Voltage Measurements

In order to facilitate checking the performance of the detector if trouble is encountered and the detector is suspected, the following table of voltages as indicated on a high resistance d-c voltmeter (20,000 ohms per volt) is included. The voltages indicated in all cases are measured from the element indicated to the chassis ground and are to be considered as only approximate.

* Bell Telephone Laboratories KS-15560-L1 or equivalent.

7-5. Before making these measurements the detector controls should be prepared as follows:

Apply a power voltage of 120 ± 1V-60 cycles to J7.
Short circuit the input jack, J1.
Operate the AVC switch to its "OFF" position.
Place the HORIZONTAL GAIN control in its extreme counter-clockwise position. Place the phase dial to the point marked "0" and adjust the other controls so that the cathode ray tube functions at normal intensity and focus.

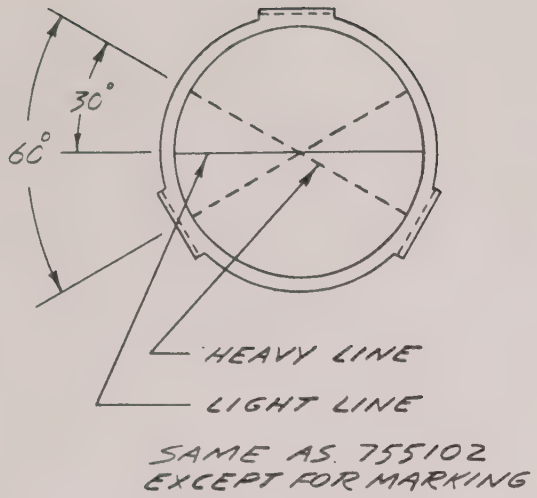
DC Voltage Measurements
Typical Average Values

B+ = 350V

Ref Sym	Type	PIN NUMBER 1	2	3	4	5	6	7	8	9	10	11	12
V1	403A	0	2.5	0	6.3	72	90	---					
V2	6BH6	-.1	.94	6.3	12.6	100	116	.94					
V3	6BH6	100	105	X	X	260	260	105					
V4	6AC7	0	X	.95	-.1	.95	110	0	127				
V6	6J5	0	X	330	---	14	340	0	106				
V8	6SL7	27	300	30	27	300	30	X	0				
V9	6SL7	0	215	2.2	0	215	2.25	X	0				
V10	2BP1	X	-290	-270	-135	---	225	225	285	285	275	---	---

--- not connected to a tube element

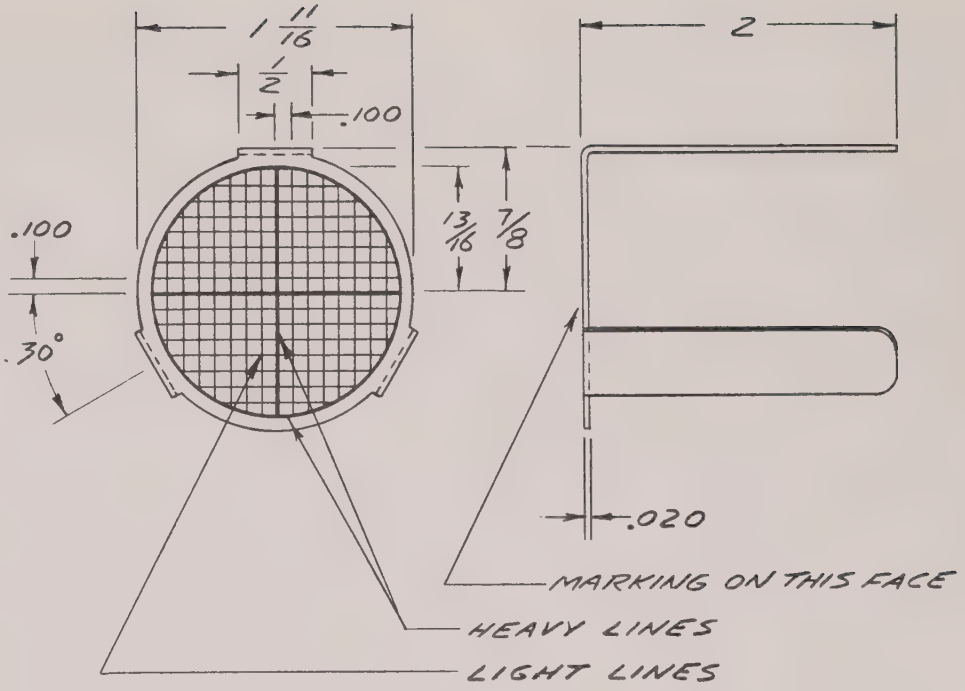
X AC only



CRT SCALE

BOONTON ELECTRONICS
755101

BELL TELEPHONE LABS
ESP 664065 DET. 2



CRT SCALE

BOONTON ELECTRONICS
755102

BELL TELEPHONE LABS
ESP 664065 DET. 1

Figure 1

CRT Scales

830,163A

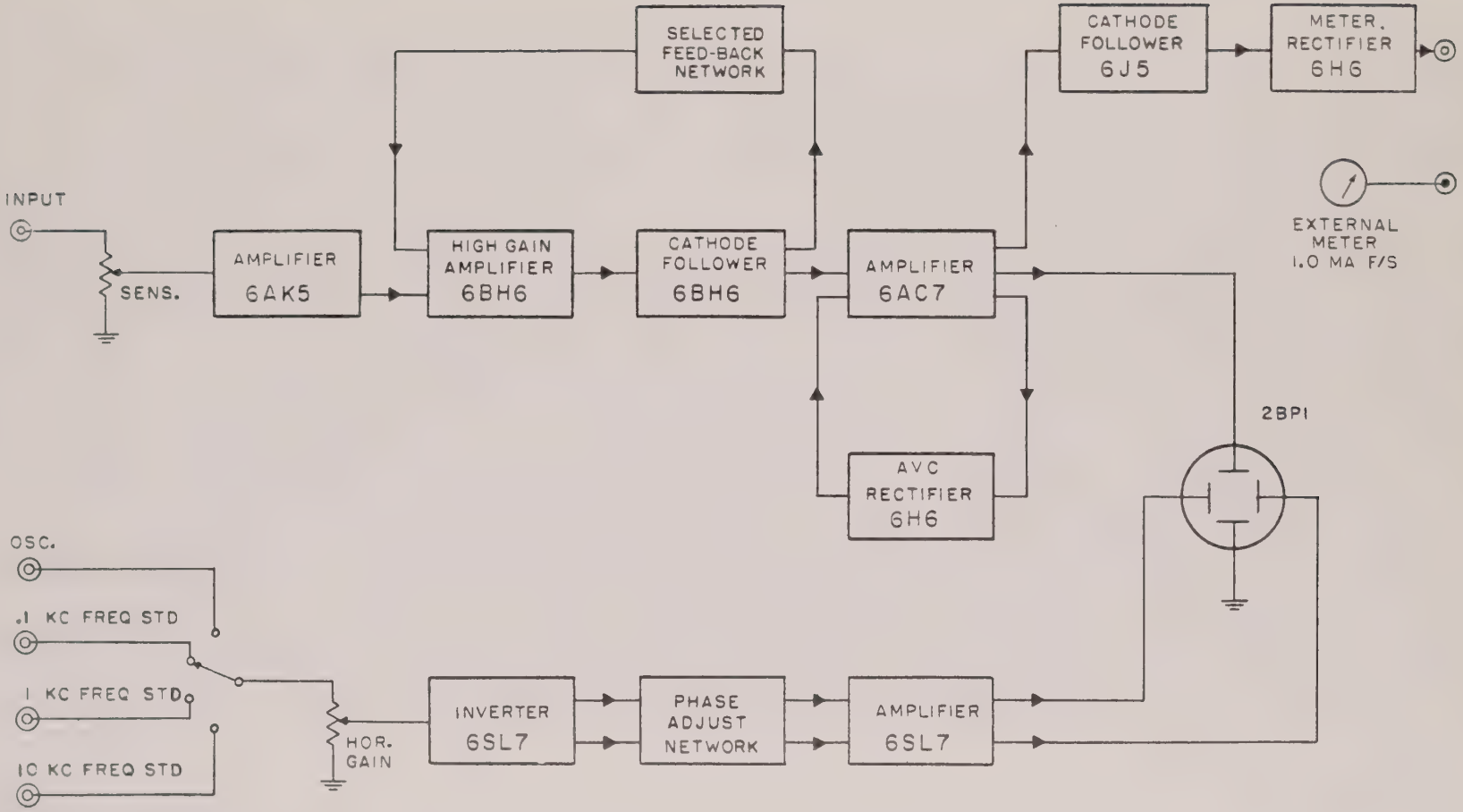


Figure 1

Block Diagram for 51A AC Null Detector

SECTION VIII

REPLACEABLE PARTS LIST

Note:

Components in the "Freq. Range Switch Section" (S4) have not been included, since in general their replacement must be followed by adjustments that require specialized equipment and techniques.

Reference		Description	BEC Part No.
C1	Capacitor	0.1 µf @ 400V	230,124
C2 A	"	30 µf @ 450V	283,122
C2 B	"	30 µf @ 450V	
C2 C	"	40 µf @ 450V	
C2 D	"	40 µf @ 450V	
C3	"	0.5 µf @ 400V	230,118
C4	"	2.2 µµf @ 600V	224,108
C5	"	2.2 µµf @ 600V	224,108
C6	"	2.0 µf @ 400V	230,137
C7	"	24 µµf @ 500V	201,132
C8	"	0.5 µf @ 400V	230,118
C9	"	0.1 µf @ 400V	230,124
C10	"	1000 µf @ 25V	283,123
C11	"	0.1 µf @ 400V	230,124
C12	"	0.1 µf @ 400V	230,124
C13	"	0.1 µf @ 400V	230,124
C14	"	1.0 µf @ 1000V	230,123
C15 A	"	0.25 µf @ 600V	283,125
C15 B	"	0.25 µf @ 600V	
C15 C	"	0.25 µf @ 600V	
C16	"	2.0 µf @ 200V	230,100
C17	"	0.1 µf @ 400V	230,124
C18	"	0.1 µf @ 400V	230,124
C19 A	"	0.1 µf @ 600V	283,124
C19 B	"	0.1 µf @ 600V	283,124
C20	"	0.1 µf @ 400V	230,124
C21	"	0.1 µf @ 400V	230,124
C22	"	0.1 µf @ 400V	230,124

Reference		Description	BEC Part No.
C23	Capacitor	0.006 µf @ 600V	230,125
C24	"	0.006 µf @ 600V	230,125
C25	"	0.1 µf @ 400V	230,124
C26	"	4.0 µf @ 600V	283,119
C27	"	10.0 µf @ 500V	283,120
C28	"	100 µf @ 450V	283,121
C29	"	100 µf @ 450V	283,121
C30 A	"	1000 µf @ 15V	283,114
C30 B	"	1000 µf @ 15V	
C31	"	220 µµf @ 500V	201,141
C32	"	1.0 µf @ 200V	234,017
C33	"	200 µµf @ 500V	200,004
C34	"	200 µµf @ 500V	200,004
C35	"	10 µf @ 450V	283,132
C36	"	10 µf @ 450V	283,132
CR-1	Rectifier	Sarkes-Tarzian 10M	532,002
D-1	Diode, Silicon	Int. Rectifier #SD500	532,005
D-2	" "	Int. Rectifier #SD500	532,005
F1	Fuse	2 Amp BUSS AGC 2	545,503
F2	Fuse	2 Amp BUSS AGC 2	545,503
L1	Choke	Stancor C-1709	440,004
NE-1	Lamp, Neon	NE-51	545,105
P1	Potentiometer	1 Meg. 2W 10%	311,139
P2	"	20.5K Special	311,132
P3	"	41K	
P4	"	41K	
P5	"	50K 2W 10%	311,125
P6	"	50K 2W 10%	311,125
P7	"	1 Meg. 2W 10%	311,133
P8	"	25K 2W 10%	311,136
P9	"	50K 2W 10%	311,125
P10	"	50K 2W 10%	311,145
P11	"	50K 2W 10%	
P12	"	1 Meg. 2W 10%	311,133
P13	"	1 Meg. 2W 10%	311,133

Reference		Description			BEC Part No.
R1	Resistor	11K	1/2W	1%	306,696
R2	"	1K	1W	5%	302,101
R3	"	10K	1W	5%	302,125
R4	"	100K	1W	5%	302,149
R5	"	23K	1/2W	0.5%	321,264
R6	"	1 Meg.	1/2W	5%	301,159
R7	"	220 Ω	1/2W	5%	301,071
R8	"	23K	1/2W	0.5%	321,264
R9	"	180K	1W	5%	302,155
R10	"	47K	1W	5%	302,141
R11	"	56K	2W	5%	304,129
R12	"	1 Meg.	1/2W	5%	301,159
R13	"	22K	1W	5%	302,133
R14	"	100K	1W	5%	302,149
R15	"	390K	1/2W	5%	301,149
R16	"	18K	1W	5%	302,131
R17	"	100 Ω	1W	5%	302,077
R18	"	56 Ω	1/2W	5%	301,057
R19	"	15K	4W	5%	
	M/R (2)	30K	2W	5%	304,122
R20	Resistor	62K	1W	5%	302,144
R21	"	510K	1/2W	5%	301,152
R22	"	100K	1W	5%	302,149
R23	"	1 Meg.	1/2W	5%	301,159
R24	"	680 Ω	1/2W	5%	301,083
R25	"	10K	1W	5%	302,125
R26	"	1 Meg.	1/2W	5%	301,159
R27	"	1K	1/2W	5%	301,087
R28	"	47K	1/2W	5%	301,127
R29	"	100 Ω	1/2W	5%	301,063
R30	"	1 Meg.	1/2W	5%	301,159
R31	"	56K	1W	5%	302,234
R32	"	56K	1W	5%	302,234
R33	"	24K	1W	5%	302,134
R34	"	270K	1/2W	5%	301,145
R35	"	1 Meg.	1/2W	5%	301,159
R36	"	2K	1W	5%	302,108
R37	"	10K	1W	5%	302,125
R38	"	10K	1W	5%	302,125
R39	"	6.8K	1W	5%	302,121
R40	"	1 Meg.	1/2W	5%	301,159
R41	"	1 Meg.	1/2W	5%	301,159

Reference		Description	BEC Part No.
R42	Resistor	150K 2W 5%	304,139
R43	"	100K 1W 5%	302,149
R44	"	100K 1W 5%	302,149
R45	"	2K 1W 5%	302,108
R46	"	1 Meg. 1/2W 5%	301,159
R47	"	510K 1/2W 5%	301,152
R48	"	510K 1/2W 5%	301,152
R49	"	510K 1/2W 5%	301,152
R50	"	1000 Ω 10W 20%	312,105
R51	"	1000 Ω 5W 20%	312,104
R52	"	20 Ω 20W 20%	312,500
R53	"	240 Ω 1/2W 5%	301,072
R54	"	3.3K 1/2W 5%	301,099
R55	"	1K 1W 5%	302,101
R56	"	15K 1/2W 10%	301,115
R57	"	3.3K 1/2W 10%	301,016
R58	"	10K 1/2W 10%	301,019
R59	"	100K 1/2W 10%	301,025
R60	"	150K 1W 10%	302,026
S1	Switch	SPSP, Carling 216-62	465,100
S2	"	SPST, Carling 216-62	465,100
S3	"	SP4T, CRL 2501	466,121
T1	Transformer	Stancor PC 8410	446,009
T2	Transformer	Stancor P-8130	446,010
V1	Tube	6AK5	526,6AK5
V2	"	6BH6	526,6BH6
V3	"	6BH6	526,6BH6
V4	"	6AC7	526,6AC7
V5	"	6H6	526,6H6
V6	"	6J5	526,6J5
V7	"	6H6	526,6H6
V8	"	6SL7	526,6SL7
V9	"	6SL7	526,6SL7
V10	CR Tube	2BP1	526,2BP1
V11	Tube	5U4G	526,5U4G

SECTION IX

SHIPPING INSTRUCTIONS

9-1. If it becomes necessary to ship the instrument for any reason, wrap the unit with heavy wrapping paper and seal the seams with gummed tape. Place the instrument into a fibreboard carton large enough to allow at least three inches of soft packing material to be placed between the instrument and the sides of the box.

WARRANTY

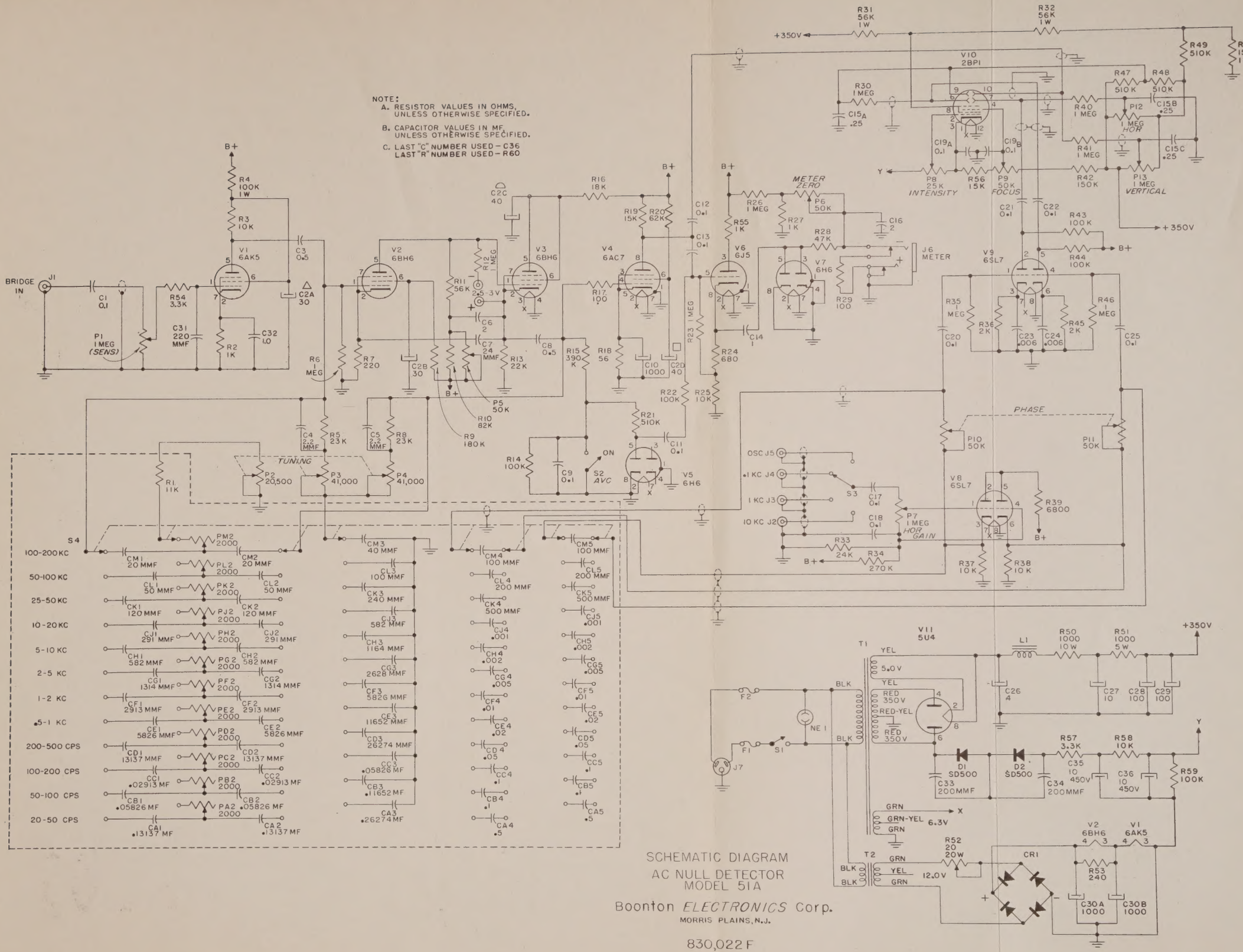
BOONTON ELECTRONICS CORPORATION guarantees to the original purchaser that each instrument it manufactures be free from defects in material and workmanship for a period of one year after date of initial shipment. Our liability is limited to repairing or replacing any defective part with the exception of vacuum tubes, panel lamps, fuses and batteries. The warranty lapses if, upon our examination, we judge that the instrument has been abused in any way.

PROCEDURE TO FOLLOW WHEN INSTRUMENT IS DEFECTIVE

1. Call our plant or our representative nearest you. A simple solution may result from discussion of the problem with our trained personnel.

2. If the fault is not readily eliminated, prepare the instrument for return to us. Pack carefully in a sturdy container using several inches of shock absorbing material on all six sides of the instrument. Include all probes, cables, or accessory units. On all paper work pertaining to the returned instrument, note the model and serial number and state briefly the details of the fault. Ship to us transportation charges prepaid.

3. If the instrument is within the warranty, we will repair and return to you transportation charges prepaid. If the instrument is beyond the one year warranty period, we will repair and return it unless approval on a cost estimate is requested. If the instrument is within the one year warranty period, but our examination reveals abuse, we will await approval of our cost estimate before proceeding with repairs.



SCHEMATIC DIAGRAM
AC NULL DETECTOR
MODEL 51A

Boonton *ELECTRONICS* Corp.
MORRIS PLAINS, N.J.

830,022 F

MP MASTER
MA24684